SOME MESOZOIC ADHERENT FORAMINIFERA

by TOM BARNARD

ABSTRACT. The relationships between certain common Mesozoic species of adherent foraminifera are discussed. The wall structure appears to be the deciding factor in the correct placing of these genera. One new genus *Arenonina*, with type species *Arenonina cretacea* sp. nov., is proposed. An account of the evolution of the *Bullopora–Vitriwebbina* group is given. Most of the important species of Mesozoic adherent foraminifera are figured, although full synonymies are not considered desirable at this stage in our knowledge.

INTRODUCTION

SINCE Quenstedt (1856) gave the first description of an adherent foraminifer from the Lias, the subject has gradually become involved due to the introduction of new genera and species. In spite of an attempt by Macfadyen (1941) to clear up some of the problems, a number of recent papers has added to the confusion, so that further work on this group of foraminifera seemed necessary.

The present author has collected material from many levels in the Mesozoic, and found specimens adhering to crinoid ossicles and pinnules, fragments of shells of lamellibranchs, brachiopods, and echinoids. A few were also found adhering to inorganic fragments, mostly ooliths. In thin-sections of oolitic limestones from the Middle and Upper Jurassic many foraminifera were seen to be fixed to ooliths.

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Problems of nomenclature. The chief problems involved in a study of fossil adherent foraminifera are due to the inadvertent mixing of genera by some authors. This is perhaps due to the different states of preservation of the specimens. In most cases it is necessary to make extensive use of thin-sections to determine the wall structure. Authors often remark on the colour of specimens, giving the impression that milky-white tests are imperforate porcellaneous foraminifera. In many cases this is not true, however, and a grade in colour is found within one species, due to different states of preservation.

The initial ends of specimens are not often preserved and this too has led to confusion, especially where end-chambers are similar in shape.

In the present paper the chief 'genera' discussed are *Ammovertella*, *Bdelloidina*, *Bullopora*, *Nubeculinella*, *Placopsilina*, *Tolypammina*, *Vitriwebbina*, and *Webbina*.

DISCUSSION OF CERTAIN GENERA

(*a*) *Forms with agglutinated tests*

Genus TOLYPAMMINA Rhumbler 1895

Type species *Hyperammina vagans* Brady

Rhumbler (1895) separated the genus *Tolypammina* from *Hyperammina* on account of the adherent nature of the former, describing it as 'Gehäuse mehr oder weniger festgewachsen, mit kugliger oder ovaler Anfangskammer, sonst eine gleich weite Rohre dar-

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stellend, welche sich in unregelmäßigen Hin- und Herwindungen aufknäuelt'. The figure of the type *H. vagans* Brady, differs somewhat from the Mesozoic adherent forms in having a more tortuous shape.

A study of the type specimen preserved in the Brady Collection, British Museum (Natural History), together with material from the Challenger and Porcupine Collections, reveals that the specimens differ appreciably from the description given by Cushman (1940, p. 95), and assumed to be correct by many workers.

Brady's specimens show no sign of an initial coiled portion, but consist of a globular proloculum, followed by an irregularly winding tube. Many forms described as *Tolypammina* have an initial coiled portion, for example *Tolypammina delicatula* Cushman and Waters (1928, p. 62, pl. 8, fig. 3), and these forms should be transferred to *Ammovertella*. Cushman (1940, p. 92) gives a copy of Brady's type figure in a 'phylogenetic' chart of the family Ammodiscidae. Hence it is apparent that Cushman places forms with or without initial coils in the same genus.

Examples of *Tolypammina* are figured on Pl. 22, figs. 3, 4; Pl. 23, fig. 1*b*.

Genus AMMOVERTELLA Cushman 1927

Type species *Ammodiscus* (*Psammophis*) *inversus* Schellwien 1898

Cushman (1927) selected *Psammophis inversus* Schellwien as the genotype for a new genus *Ammovertella*, which had previously been considered as *Psammophis*, a sub-genus of *Ammodiscus*. The form is adherent, with a planispiral initial portion, followed by an irregularly unwinding tube. The aperture is the open end of this tube. Many forms from the Mesozoic are similar to the type figure, even to the extent of having a reverse direction of coiling, a character often seen in the free foraminifera *Ammodiscus*.

In both *Tolypammina* and *Ammovertella* the final tubular portion of the test is similar, and without a study of the initial part, it is impossible to separate the genera. *Ammovertella liassica* Barnard is figured on Pl. 22, figs. 5, 6.

Genus PLACOPSILINA d'Orbigny 1850

Type species *Placopsilina cenomana* d'Orbigny

Placopsilina differs from the two genera discussed above in that it is a polythalmous form with distinct chambers. D'Orbigny (1850, p. 259) states 'Ce genre ressemble aux *Truncatulina*, mais est toujours fixe . . .'.

Originally the species was not figured by d'Orbigny, and Cushman (1920) designated *Placopsina cenomana* d'Orbigny as the type species. Cushman (1940) figures *Pl. cenomana* (after Reuss), showing a spiral initial portion, and states (p. 191) '. . . early portion close coiled, later portions uncoiled and spreading out in a generally linear series . . .'.

Many specimens of adherent vitreous foraminifera having hemispherical chambers secrete a lower boundary wall to each chamber. This rests on and adheres to the surface on which the foraminifer grows. When tests are crushed into this lower surface a pseudo-arenaceous wall is produced, and specimens belonging to *Bullopora*, *Webbina*, and *Vitriwebbina* have been included in *Placopsilina*.

Two different forms, however, do exist, one having an initial coiled stage followed by an uncoiled portion, which varies appreciably in length, and the other having no initial coil. In the former the chambers in later stages of the test abut directly against one another, with no well-marked constriction along the septa, whereas in the latter the chambers tend to be hemispherical, with constricted necks connecting them. Most forms which have been described as having an initial coil are confined to the Cretaceous. *Placopsilina expansa* Tappan (1943), *Pl. longa* Tappan (1940, 1943), and *Pl. minima* Tappan (1943) are three examples from the Lower Cretaceous of America, in which the uncoiled portion of the test is of varying length.

Many specimens from the Lias and Oolites described by Terquem as belonging to the genus *Placopsilina* were on examination found to be crushed specimens of *Bullopora rostrata* Quenstedt and *B. globulata* Barnard.

The problem arises as to what d'Orbigny's original specimens looked like. Both Reuss and Chapman figure *Pl. cenomana* d'Orbigny as having a well-marked initial coil, and if these figures are a correct interpretation of d'Orbigny's specimen, then the material from the Jurassic, having hemispherical chambers, should be assigned to a different genus. However, the present author thinks that it is undesirable to take this step until more evidence is available.

Species of *Placopsilina* are figured on Pl. 23, fig. 2, and Pl. 25, fig. 4.

Genus BDELLOIDINA Carter 1877

Type species *Bdelloidina aggregata* Carter 1877

In a recent paper Loeblich and Tappan (1955, p. 21) state that 'Carter's specimens have not been found but were from excavations on the surface of a mass of *Siderasteraea*, exact locality not given'. These authors (1955, pl. 3, figs. 9, 10) show adherent foraminifera with internal structures in the forms of interior secondary septa crossing the chambers vertically, with numerous internal pores. These characters are of sufficient generic importance to separate this genus from the specimens from the Upper Cretaceous (Chalk) of England, which otherwise have a superficial external resemblance to *Bdelloidina,* and could be confused with it. They are described below as a new genus.

Genus ARENONINA gen. nov.

Type species *Arenonina cretacea* sp. nov.

Diagnosis. Test attached, wall arenaceous, composed of fine particles in a calcareous cement. The test consists of an initial spire followed by a uniserial arrangement of the chambers. The spire consists of four to eight chambers in each whorl, and usually of less than two whorls. In the spire the chambers are triangular in plan view, and swollen so that the periphery is lobulate. Near the periphery the sutures are deep and the chambers constricted, but become shallow and indistinct towards the central umbilicus.

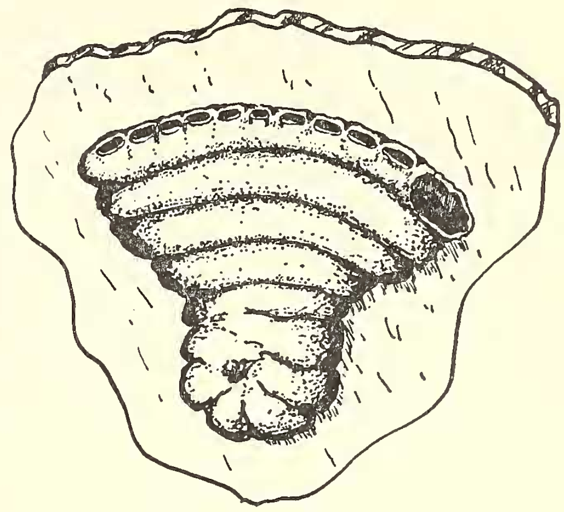
Although the height of the chambers increases slowly, the distance from the periphery to the umbilicus may increase rapidly, so that after the initial spire the chambers may overlap one another on to the earlier portion of the test. Sometimes the test tends to become loosely coiled before passing into the uniserial portion. Within the uniserial part of the test the chambers are arcuate with parallel septa, little or no increase in height, but a rapid increase in length; so that the test becomes fan-shaped.

The aperture consists of a row of well-defined pores occurring along the full length of the apertural face. Each pore has a well-marked lip. The pores increase in size towards the edge of the test.

Arenonina cretacea sp. nov.

Plate 22, figs. 1 and 2; text-fig. 1

Description. Test adherent, arenaceous wall, with much calcareous cement. The test consists of an initial loose spire, followed by a uniserial series of chambers. The spire consists of four to eight chambers, with constricted sutures. These constrictions are deep at the outer margin of the test, but tend to become shallow and indistinct towards the umbilicus. The outer margin of the test is lobulate. The initial spire is followed by two to four chambers only slightly increasing in length, forming a short arcuate portion to the test. Finally the chambers increase rapidly in length until a fan-shaped test is formed.



TEXT-FIG. 1. *Arenonina cretacea* gen. et sp. nov.

In the early stages of the test the aperture appears to be a longitudinal slit running the full length of the apertural face. The specimens which show this may, however, be damaged. In forms having fan-shaped later chambers the aperture consists of a single row of pores, each pore surrounded by a distinct smooth lip. The pores increase in size from the centre of the test towards the periphery. Each pore occurs at the top of a small crenulation of the apertural face.

Holotype. British Museum (Natural History) P. 43656. Upper Chalk, Zone of *Micraster coranguinum*, Northfleet, Kent.

Range of specimens studied. Upper Chalk, Zones of *M. coranguinum* and *Belemnitella mucronata.*

(*b*) *Forms with calcareous tests*

Genus NUBECULINELLA Cushman 1930

Type species *Nubeculinella bigoti* Cushman

Cushman (1929, p. 134) selected *N. bigoti* as the genotype of *Nubeculinella*, this form coming from the Oxfordian of Auberville. Macfadyen (1941) considered that *Nubeculinella* to be a synonym of *Bullopora* Quenstedt. Most of the forms described were in fact collected from the Oxford Clay of Warboys, Huntingdonshire, and were identical with *N. bigoti* Cushman.

Sections through the walls of similar fossils show an imperforate porcellaneous wall structure, with no radially arranged calcite visible, even when highly magnified. The test has an initial globular proloculum around which the second chamber is planispirally wound. This initial part of the test is followed by a linear series of hemielliptical or elongated chambers.

Cushman's figures show the specimens to have holes on the top of the dome-shaped chambers. This is often seen in fossil forms where the wall has been partially removed. If the chambers are filled with secondary calcite and the wall removed, the form appears to have a vitreous, hyaline wall and consequently has often been assigned to *Bullopora*.

In some specimens, however, the replacement is partial, and part of the wall remains, serving as a means towards identifying the species.

After the initial spire the general shape of the chambers resembles those in *Bullopora* and further confusion exists. Two species of *Nubeculinella* are figured on Pl. 23, figs. 1*a*, 3, and Pl. 25, fig. 5.

Genus WEBBINA d'Orbigny 1839

Type species *Webbina rugosa* d'Orbigny 1839

Although d'Orbigny originally figured and described the genus (1839) a type was not designated. Loeblich and Tappan (1955, p. 23) point out that *Webbina rugosa* d'Orbigny, a Recent form, was subsequently designated by d'Orbigny in Barker-Webb and Berthelot (1839, p. 126); it was the first species published under that genus. Three authors, Galloway (1933, p. 296), Cushman (1940, p. 303), and Loeblich and Tappan (1955, p. 23) all disagree regarding the wall structure. The latter, however, state that 'the original figures given by d'Orbigny for this species are very misleading. The holotype does not appear either coarsely perforate or with a roughened surface except for the fimbriate-appearing keel.'

The question of wall structure of this form is important when considered in relation to the genera *Bullopora* and *Vitriwebbina*. Sollas (1877, p. 103) describes sections of two species, *W. laevis* and *W. tuberculata*, both from the Cambridge Greensand (Albian). These forms have radial calcite forming the wall, and are said to be perforate.

Most forms assigned to either the genus *Bullopora* or *Vitriwebbina* have a thin base to each chamber, sometimes this protrudes beyond the sides of the chambers, it may be that this character which is said to be diagnostic of *Webbina* is common to all three 'genera'.

It seems probable that the species proposed by Sollas (1877) belong to the genus *Vitriwebbina* as stated by Chapman (1892), and these forms may not be the same genus as the Recent species *W. rugosa* d'Orbigny.

Genus VITRIWEBBINA Chapman 1892

Type species *Vitriwebbina sollasi* Chapman

Chapman 1892 created the new genus *Vitriwebbina* and included part of both d'Orbigny's and Sollas's *Webbina*. Cushman (1927) designated *V. sollasi* Chapman 1892 as the type species, but later, however (1940), decided that *Vitriwebbina* was a synonym of *Bullopora*.

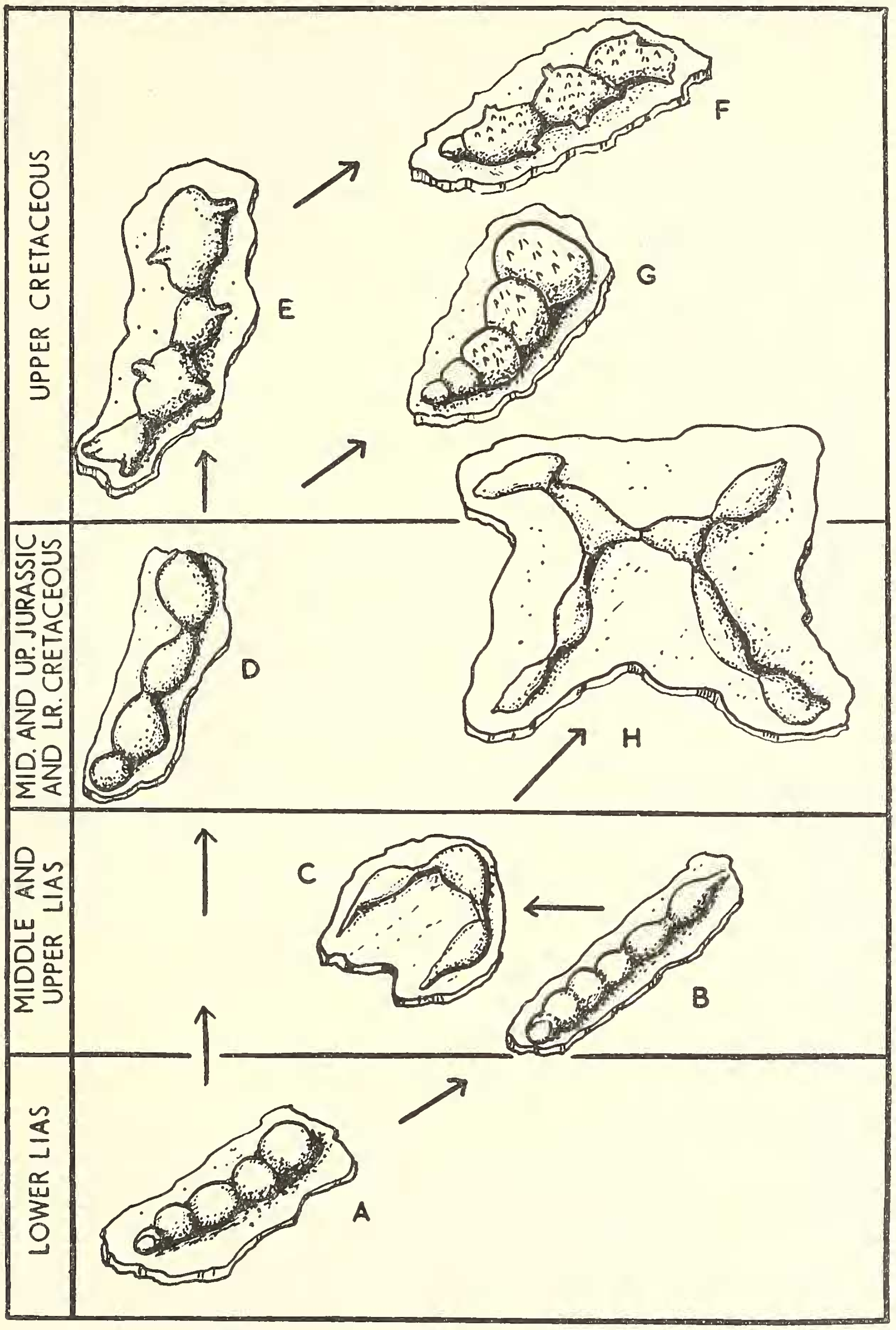
Genus BULLOPORA Quenstedt 1856

Type species *Bullopora rostrata* Quenstedt

The taxonomy of the calcareous adherent foraminifera depends on the wall structure of the genera *Webbina*, *Vitriwebbina*, and *Bullopora*, whether these forms have radial calcite forming the walls, and whether they are synonymous.

Although *Bullopora rostrata* Quenstedt was the first species to be named by Quenstedt, another form was first figured and described, but left unnamed. No type was designated and so *B. rostrata* has become the type. Quenstedt's figures, although indistinct, show the two forms to have strong differences. *Bullopora sp.* (the first described species) Quenstedt (p. 292, pl. 41, fig. 26) does not show the long tubular necks so characteristic and well marked in *B. rostrata* Quenstedt (p. 554, pl. 73, fig. 28). This fundamental difference between the two forms has been remarked on before, and the *Bullopora sp.* of Quenstedt would fall within the present author's conception of his species *Bullopora globulata* Barnard (1950*a*).

Bullopora has been referred to several different families of foraminifera. Macfadyan (1941) places it in the Ophthalminiidae, but suggests *Bullopora* is synonymous with



TEXT-FIG. 2. Outline of evolution of *Bullopora*.

Nubeculinella, an imperforate porcellaneous form. Cushman (1940) and Tappan (1943) place it in the Polymorphinidae. The present author considers *Bullopora* and *Vitriwebbina* synonymous, and that both belong to the vitreous, hyaline foraminifera. The initial part of the test consists of a hemispherical proloculum followed by a chamber which partly surrounds this, a character often seen in the non-adherent foraminifera belonging to the family Lagenidae. Thus the present author assigns the genus *Bullopora* to the family Lagenidae, with the possibility in mind that *Bullopora* may prove a synonym of *Webbina*, when more is known about the type specimen of the latter.

Examples of *Bullopora* are figured on Pl. 24 and 25.

Evolution of Bullopora. If *Vitriwebbina* and *Bullopora* are synonymous, then an account of their evolution throughout the Mesozoic can be given (text-fig. 2).

EXPLANATION OF PLATE 22

All illustrations are unretouched photographs and all are magnified ×30 except fig. 6 which is ×60. Unless otherwise stated the specimens are in the author's collection.

Figs. 1–2. *Arenonina cretacea* gen. et sp. nov. 1, Holotype, Upper Cretaceous, Zone of *Micraster coranguinum*, Northfleet, Kent. British Museum (Nat. Hist.) P. 43656. 2, Paratype, Upper Cretaceous, Zone of *Belemnitella mucronata*, Paulsgrove, Norfolk.

Figs. 3–4. *Tolypammina flagellum* (Terquem). 3, Upper Lias, Zone of *Dactylioceras tenuicostatum*, Byfield, Northamptonshire. 4, Lower Lias, Zone of *Scamnoceras angulatum*, Lyme Regis, Dorset.

Figs. 5–6. *Ammovertella liassica* Barnard. 5, Fuller's Earth, Bathonian, Langton Herring, Dorset. 6, Upper Lias, Zone of *Dactylioceras tenuicostatum*, Byfield, Northamptonshire.

EXPLANATION OF PLATE 23

All illustrations are unretouched photographs. The specimens are in the author's collection.

Fig. 1. (*a*) *Nubeculinella bigoti* Cushman, ×30. (*b*) *Tolypammina flagellum* (Terquem), ×30. Upper Oxford Clay, Zone of *Cardioceras praecordatum*, Warboys, Huntingdonshire.

Fig. 2. *Placopsilina sp.*, ×60. Lower Lias, Zone of *Scamnoceras angulatum*, Lyme Regis, Dorset.

Fig. 3. *Nubeculinella filiformis* Paalzow, ×45. Upper Lias, Zone of *Dactylioceras tenuicostatum*, Byfield, Northamptonshire.

EXPLANATION OF PLATE 24

All illustrations are unretouched photographs and all are magnified ×30. All specimens except where otherwise stated are in the author's collection.

Fig. 1. *Bullopora sollasi* var. *gonoidea* (Chapman). Holotype, Gault Clay, Copt Point, Folkestone, Kent. British Museum (Nat. Hist.) P. 5249.

Fig. 2. *Bullopora sollasi* (Chapman). Holotype, Gault Clay, Copt Point, Folkestone, Kent. British Museum (Nat. Hist.) P. 4719.

Fig. 3. *Bullopora* cf. *globulata* Barnard. Upper Cretaceous, Zone of *Belemnitella mucronata*, New Catton, Norwich, Norfolk.

Fig. 4. *Bullopora rostrata* Quenstedt. Upper Oxford Clay, Zone of *Cardiocera praecordatum*, Warboys, Huntingdonshire.

Fig. 5. *Bullopora globulata* Barnard. Lower Lias, Zone of *Scamnoceras angulatum*, Lyme Regis, Dorset.

Fig. 6. *Bullopora rugosa* d'Orbigny. Cenomanian, Barrington, Cambridgeshire.

EXPLANATION OF PLATE 25

All illustrations are unretouched photographs and all are magnified ×30 except fig. 2 which is ×10. All specimens except where otherwise stated are in the author's collection.

Fig. 1. *Bullopora sollasi* var. *gonoidea* (Chapman). Upper Cretaceous, Taylor Formation, Texas.

Fig. 2. ? *Neoflabellina* cf. *angulosa* (d'Orbigny). Upper Chalk, Zone of *Belemnitella mucronata*, Tharston, Norfolk.

Fig. 3. *Bullopora* cf. *globulata* Barnard. Upper Cretaceous, Zone of *Belemnitella mucronata*, New Catton, Norwich, Norfolk.

Fig. 4. *Placopsilina cenomana* d'Orbigny. Cenomanian, Barrington, Cambridgeshire.

Fig. 5. (*a*) *Nubeculinella bigoti* Cushman. (*b*) *Bullopora rostrata* Quenstedt. Upper Oxford Clay, Zone of *Cardioceras praecordatum*, Warboys, Huntingdonshire.

Figs. 6–7. *Bullopora* cf. *rostrata* Quenstedt. Upper Cretaceous, Taylor Formation, Texas.

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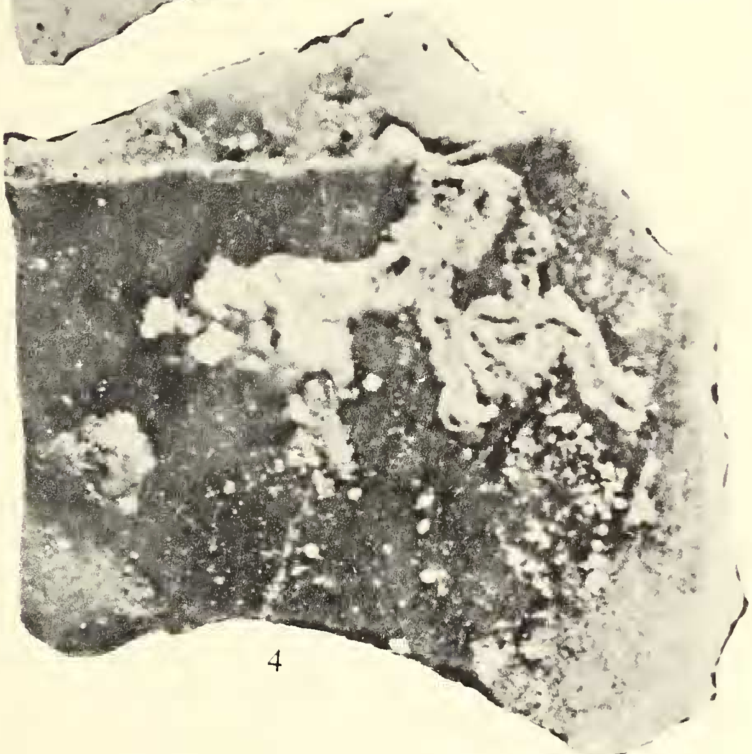

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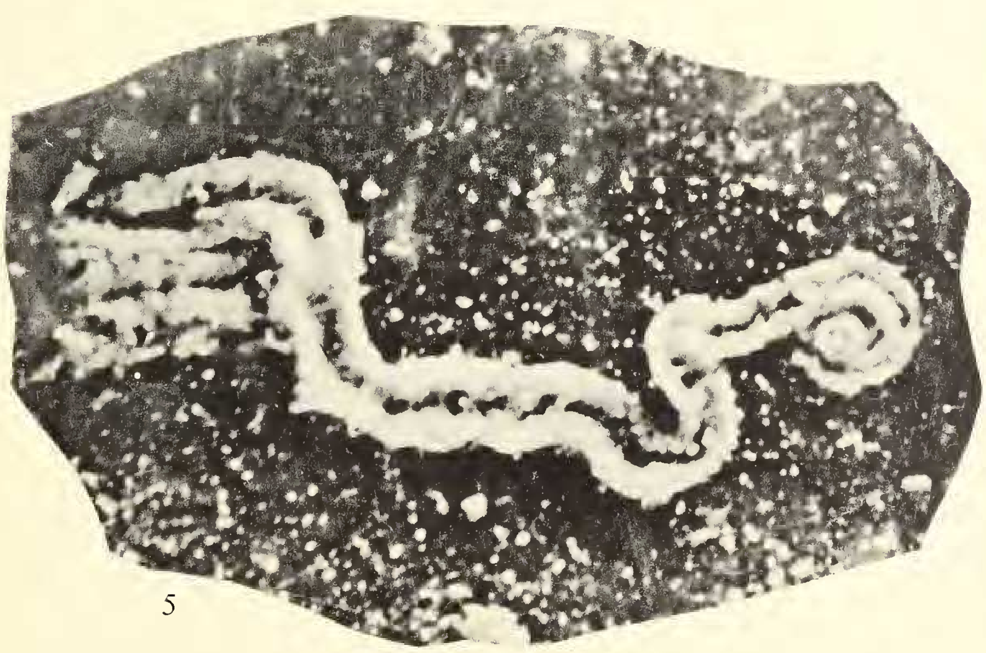

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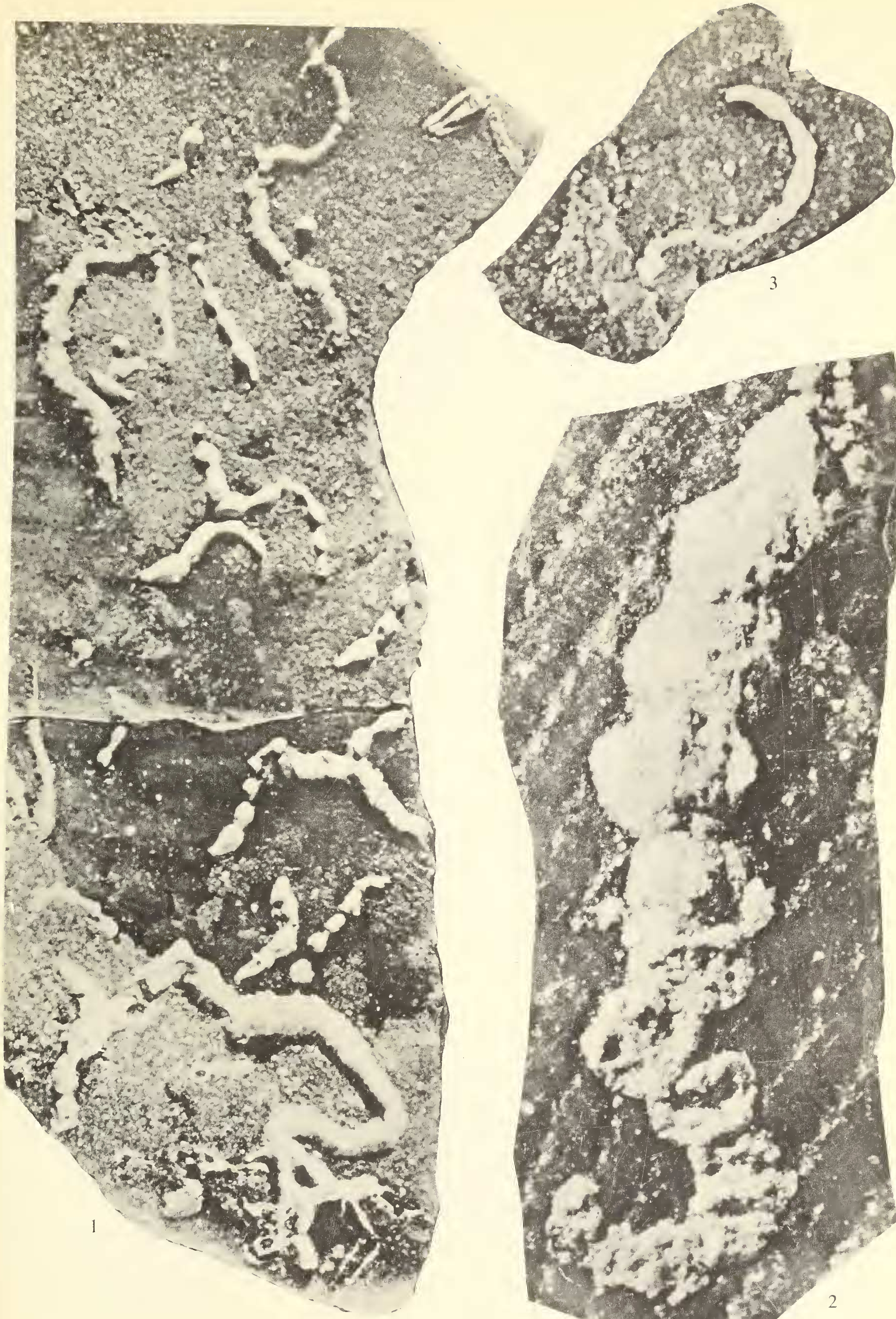
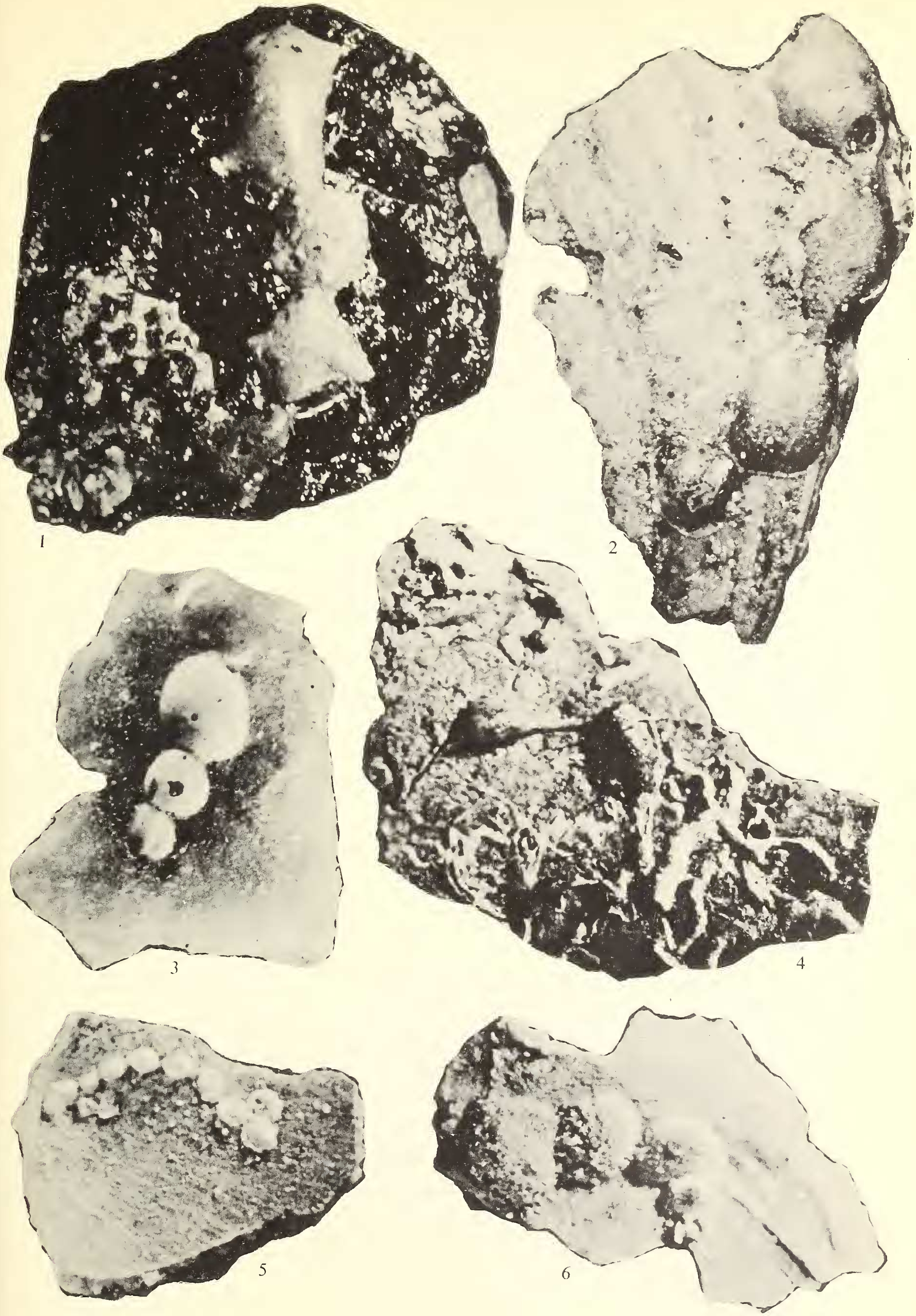
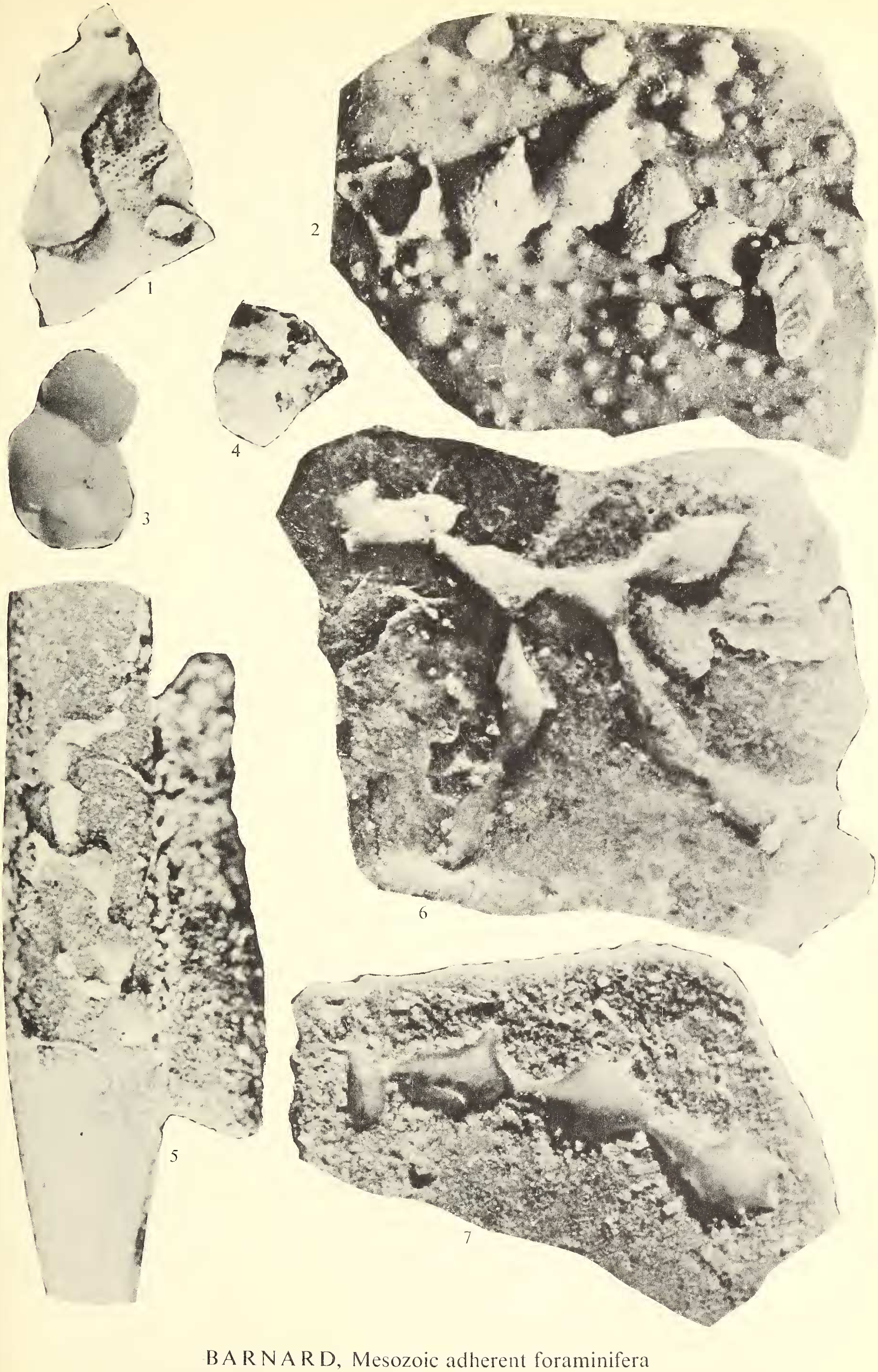
BARNARD, Mesozoic adherent foraminifera



BARNARD, Mesozoic adherent foraminifera



BARNARD, Mesozoic adherent foraminifera



BARNARD, Mesozoic adherent foraminifera

Form A shows a normal specimen of *Bullopora globulata* Barnard, which occurs in the Lower Lias and continues almost unchanged to the Cretaceous, where it has been called *Vitriwebbina laevis* (Sollas) by most authors.

In many Lagenids there is a tendency for later chambers to become elongate and constrictions to occur between the chambers. This is seen in Form B, occurring in the Middle and Upper Lias, *Bullopora rostrata* Quenstedt and *B. globulata* Barnard could be linked through this form. When the elongate constricted chambers occur after the second chamber, the Form C, *Bullopora rostrata* Quenstedt is developed. This form ranges from Middle Lias to Cretaceous, where it may show a tendency to branch, as in Form H. All these forms A, B, C, D, H have unornamented chambers with smooth peripheries.

Later in the Cretaceous two further trends develop. Form E shows a tendency for some of the chambers to develop small tubular extensions, which often become extended and fix on to small objects or irregularities on the host body, for instance the granules on echinoids.

Independently of this a further trend may be developed as in Forms F and G which have a hispid or rugose ornament. In some specimens early chambers are smooth and later ones are ornamented. This feature can occur in both forms, those with smooth peripheries and those with tubular extensions to the chambers.

The author (1949, p. 284) drew attention to a group of specimens showing a passage from a free unornamented *Neoflabellina* to an adherent hispid *Bullopora*. The question arises how this peculiar group, with what appears to be two distinctly different generic forms mixed in one specimen, could have arisen.

For a long time a similar, but less pronounced, problem has presented itself to the author in his studies of other members of the Lagenidae, particularly short-ranged forms which appear to be made up of two generic forms. The suggestion is put forward that these forms may have arisen as hybrids from interbreeding between two genera.

As far as the author has been able to ascertain, the form on Pl. 25, fig. 2 is the only one described which changes not only its growth pattern, but also its mode of life, from a free to a fixed species.

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